CLAIMS

What I claim is

1. A method of decoding a concatenated convolutional encoded and block encoded signal, the method comprising the steps of:

a) applying the encoded signal to first Viterbi decoder means and delay means to form a delayed encoded signal;

b) decoding the encoded signal with the first Viterbi decoder means to form a first Viterbi decoded signal;

c) de-interleaving the first Viterbi decoded signal with first de-interleaver means to form a first de-interleaved signal;

d) block decoding the first de-interleaved signal, with first block decoder means, identifying correctly decoded blocks and marking decoded bits identified as belonging to the correctly decoded blocks to form a marked decoded signal;

e) interleaving the marked decoded signal using first interleaver means for output to second Viterbi decoder means;

f) decoding the delayed encoded signal with the second Viterbi decoder means using the interleaved marked decoded signal by: for each received encoded symbol representative of a bit in an original signal encoded with a convolutional encoder and block encoder to form the concatenated convolutional encoded and block encoded signal, adding, for each possible current state of the convolutional encoder, error coefficients representative of differences between the received encoded symbol, representative of a transition from a previous state to a current state, and expected symbols corresponding to predetermined permitted transitions from previous states to the current state, to a sum of such error coefficients for said previous states to form updated sums of such error coefficients for each of a new plurality of state sequences for all possible states;

determining whether the bit is a marked decoded bit and if the bit is a marked decoded bit, for every state, selecting both a most probable state sequence ending in that state from the new plurality of state sequences and a corresponding updated sum of error coefficients according to said predetermined bit, thereby discounting, at a bit location in the encoded signal corresponding to the marked decoded bit, any state inconsistent with the marked decoded bit; if the bit is not a marked decoded bit, for every state, comparing said updated sums of error coefficients and selecting an updated sum of error coefficients representing a lesser total of said differences between the received encoded symbols and the expected symbols and selecting a corresponding most probable state sequence ending in that state from the new plurality of state sequences; determining a best current state for the bit in the original signal by one of comparing the updated sums of error coefficients of the most probable state sequences for every state and choosing a state arbitrarily; and thereby determining, by tracing back from the best current state, a most probable earliest transition and earliest state that occurred a predetermined plurality of symbols previously, and outputting a bit most probably equal to the bit in the original signal to form a second Viterbi decoded signal;

g) de-interleaving the second Viterbi decoded signal with second de-interleaver means to form a second de-interleaved signal; and

h) block decoding the second de-interleaved signal with second block decoder means to form a decoded output signal.

2. A method as claimed in claim 1, wherein the method includes further iterative steps after step h) of using further delay means further to delay the delayed encoded signal and repeating at least once steps e) to h) to decode the further delayed encoded signal using known bits from the decoded output signal from step h).

3. A method as claimed in claim 1, wherein the step of decoding the delayed encoded signal comprises determining a Viterbi state trellis corresponding to a convolutional code used to encode the encoded signal, adding and comparing error coefficients of transition paths of the delayed encoded signal through the Viterbi state trellis to select a most probable transition path, while ignoring at a location in the delayed encoded signal corresponding to the marked decoded bits in the marked decoded signal any state in the Viterbi state trellis not consistent with the marked decoded bits and any transition path passing through such a state, thereby determining, from the most probable transition path, a second Viterbi decoded signal having a least number of errors taking into account the marked decoded bits in the marked decoded signal.

4. A method as claimed in claim 1 wherein the step of block decoding comprises Reed-Solomon block decoding.

5. A method as claimed in claim 1, wherein the original signal has at least one predetermined bit at a predetermined bit location, and the step of decoding the encoded signal with the first Viterbi decoder means comprises:

a) for each received encoded symbol of the encoded signal representative of a bit in the original signal, adding, for each possible current state, error coefficients representative of differences between the received encoded symbol, representative of a transition from a previous state of the convolutional encoder to a current state, and expected symbols corresponding to predetermined permitted transitions from previous states to the current state, to a sum of such error coefficients for said previous states to form updated sums of such error coefficients for each of a new plurality of state sequences for all possible states;

b) if the bit is a predetermined bit, for every state, selecting both a most probable state sequence ending in that state from the new plurality of state sequences and a corresponding updated sum of error coefficients according to said predetermined bit, thereby

discounting, at the bit location in the encoded signal corresponding to the predetermined bit location in the original signal, any state inconsistent with the predetermined bit at the predetermined bit location;

c) if the bit is not a predetermined bit, for every state, comparing said updated sums of error coefficients and selecting an updated sum of error coefficients representing a lesser total of said differences between the received encoded symbols and the expected symbols and selecting a corresponding most probable state sequence ending in that state from the new plurality of state sequences;

d) determining a best current state for the bit in the original signal by either comparing the updated sums of error coefficients of the most probable state sequences for every state or choosing a state arbitrarily; and

e) thereby determining, by tracing back from the best current state, a most probable earliest transition and earliest state that occurred a predetermined plurality of symbols previously, and thereby finding and outputting a bit most probably equal to the bit in the original signal.

6. A method as claimed in claim 5, wherein the step of adding sums of error coefficients comprises the steps of:

a) determining a Viterbi state trellis corresponding to a convolutional code used to encode the encoded signal; and

b) adding sums of error coefficients of transition paths of the encoded signal through the Viterbi state trellis to select a most probable transition path.

7. A method as claimed in claim 5, wherein the at least one predetermined bit at a predetermined bit location is a synchronisation bit.

8. A decoder for decoding a concatenated convolutional encoded and block encoded signal derived from an original signal, comprising:

receiving means for receiving the encoded signal;

applying means connected to the receiving means and to first Viterbi decoder means and first delay means for applying the encoded signal thereto;

first de-interleaver means connected to the first Viterbi decoder means for de-interleaving a decoded signal received from the first Viterbi decoder means to form a first de-interleaved signal;

first block decoder means connected to the first de-interleaver means for block decoding the first de-interleaved signal, identifying correctly decoded blocks and marking decoded bits identified as belonging to the correctly decoded blocks to form a marked decoded signal;

first interleaver means connected to the first block decoder means for interleaving the marked decoded signal;

second Viterbi decoder means connected to the first interleaver means and to the first delay means for decoding a delayed encoded signal received from the first delay means using the marked decoded signal by: for each received encoded symbol of the delayed encoded signal representative of a bit in the original signal, adding, for each possible current state of a convolutional encoder used to encode the convolutional encoded and block encoded signal, error coefficients representative of differences between the received encoded symbol, representative of a transition from a previous state of the encoder to a current state, and expected symbols corresponding to predetermined permitted transitions from previous states to the current state, to a sum of such error coefficients for said previous states to form updated sums of such error coefficients for each of a new plurality of state sequences for all possible states; if the bit is a marked decoded bit, for every state, selecting both a most probable state sequence ending in that state from the new plurality of state sequences and a corresponding updated sum of

error coefficients according to said predetermined bit, thereby discounting, at a bit location in the encoded signal corresponding to the marked decoded bit, any state inconsistent with the marked decoded bit; if the bit is not a marked decoded bit, for every state, comparing said updated sums of error coefficients and selecting an updated sum of error coefficients representing a lesser total of said differences between the received encoded symbols and the expected symbols and selecting a corresponding most probable state sequence ending in that state from the new plurality of state sequences; determining a best current state for the bit in the original signal by one of comparing the updated sums of error coefficients of the most probable state sequences for every state and choosing a state arbitrarily; and thereby determining, by tracing back from the best current state, a most probable earliest transition and earliest state that occurred a predetermined plurality of symbols previously, and outputting a bit most probably equal to the bit in the original signal;

second de-interleaver means connected to the second Viterbi decoder means for de-interleaving a signal received from the second Viterbi decoder means to form a second de-interleaved signal;

second block decoder means connected to the second de-interleaver means for block decoding the second de-interleaved signal to form a decoded output signal; and

transmitting means connected to the second block decoder means for transmitting the decoded output signal.

9. A decoder as claimed in claim 8, comprising second delay means, and second interleaver means, third Viterbi decoder means, third de-interleaver means and third block decoder means for carrying out one or more decoding iterations to decode a further delayed encoded signal from the second delay means using known bits of the decoded output signal from a previous iteration.

10. A decoder as claimed in claim 8, wherein the second Viterbi decoder means is arranged to determine a Viterbi state trellis corresponding to a convolutional code used to encode the encoded signal, to add and compare error coefficients of transition paths of the delayed encoded signal through the Viterbi state trellis to select a most probable transition path, while ignoring at a location in the delayed encoded signal corresponding to the marked decoded bits in the marked decoded signal any state in the Viterbi state trellis not consistent with the marked decoded bits and any transition path passing through such a state, thereby to determine, from the most probable transition path, a second Viterbi decoded signal having a least number of errors taking into account the marked decoded bits in the marked decoded signal.

11. A decoder as claimed in any of claim 8, wherein each of the block decoding means comprises Reed-Solomon block decoding means.

12. A decoder as claimed in any of claim 8, for decoding an encoded signal having at least one predetermined bit at a predetermined bit location, wherein the first Viterbi decoder means comprises:

summing means for adding for each received encoded symbol representative of a bit in the original signal, and for each possible current state, error coefficients representative of differences between the received encoded symbol, supposedly representative of a transition from a previous state of the encoder to a current state, and expected symbols corresponding to predetermined alternative permitted transitions from previous states to the current state, to a sum of such error coefficients for said previous states to form updated sums of such error coefficients for each of a new plurality of state sequences for all possible states,

comparing and selecting means for: if the bit is a predetermined bit, for every state, selecting both a most probable state sequence ending in that state from the new plurality of state sequences and a corresponding updated sum of error coefficients according to said predetermined bit, thereby discounting, at a bit location in the encoded signal corresponding to the

predetermined bit location in the original signal, any state inconsistent with the predetermined bit at the predetermined bit location; and, if the bit is not a predetermined bit, for every state comparing said updated sums of error coefficients and selecting an updated sum of error coefficients representing a lesser total of said differences between the received encoded symbols and the expected symbols and selecting a corresponding most probable state sequence ending in that state from the new plurality of state sequences; and

processing means for determining a best current state for the bit in the original signal by either comparing the updated sums of error coefficients of the most probable state sequences for every state or choosing a state arbitrarily; and thereby determining, by tracing back from the best current state, a most probable earliest transition and earliest state that occurred a predetermined plurality of symbols previously, and thereby finding a bit most probably equal to the bit in the original signal.

13. A decoder as claimed in claim 12, wherein the first Viterbi decoder means is arranged to:

determine a Viterbi state trellis corresponding to a convolutional code used to encode the encoded signal; and

add sums of error coefficients of transition paths of the encoded signal through the Viterbi state trellis to select a most probable transition path.

14. A decoder as claimed in claim 12, wherein the at least one predetermined bit at a predetermined bit location is a synchronisation bit.